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DRAWINGS ATTACHED

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(54) MARINE PROPULSION SYSTEM

(71) I, ALEC BURTON MITCHELL, a British subject of Admiralty Research Laboratory, Teddington, Middlesex, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a marine propulsion unit.

One of the major outstanding problems yet to be solved in the development of ocean-going hover and hydrofoil craft is the design of an optimum propulsion system. Air propulsion by means of jets or open or ducted propellers has the disadvantages — whose magnitudes increase rapidly as craft sizes grow above a hundred tons —of low efficiencies, vulnerability and of restricting deck space and use. The alternative of underwater propulsion by means of conventional shaft driven propellers also suffers disadvantages such as increased weight and low efficiency due to cavitation and the high drag penalty incurred by the propeller transmission shafts. Even the use of higher revving supercavitating propellers only partly ameliorates the transmission problems but introduce new difficulties of achieving adequate low speed and vibration-free performance. As craft speeds and sizes increase so does the required horsepower with the result thaat the more compact higher revving power plants which become necessary further aggravate the transmission problems.

The gas-water hydroduct, from which the present propulsion unit is derived, provides a partial solution to the propulsion problems of hydrofoil and hovercraft. The gas-water hydroduct operates solely on hot or cold compressed gas and so obviates the restrictions and embarrassing penalties associated with shaft/propeller systems. Performance-wise it has the advantage that, as the compression ratio increases with forward speed, so also does the propulsion efficiency for a given thrust per unit area loading. Nevertheless its solution to the problem is only partial as suitable values of thrust per unit area and overall efficiency are certainly not reached below speeds of about 100 knots. The thrust loading at lower speeds can, however, be increased to a practically acceptable value by boosting the intake pressure to the hydroduct mixing chamber by means of an axial flow pump or pumpjet, but improving the performance of the hydroduct in this way necessitates a transmission shaft, the disadvantages of which are thereby re-introduced.

The new propulsion unit is a still further development from the pumpjet boosted hydroduct described above in that the pump is not driven via a mechanical transmission from the main power plant in the hull of the craft, but by means of a turbine which is located aft of the mixing chamber in the hydroduct itself and derives its energy from the two-phase flow. By this means all the disadvantages of the simple gas-water hydroduct such as very low thrust loadings and the self-starting problem are eliminated whilst retaining the merit of requiring only a gas flow connection to its parent power plant. (The unit can be "started" by initially turning over the pump by means of an electric motor, for example, situated in the hub, until the unit becomes self-generating.) Just as there is a very strong analogy between the hydroduct and the air ramjet, the similarity, both physically and in performance characteristics between the present invention and the simple aircraft turbo-jet engine is very close.

The invention consists of a long annular duct, by which is meant a duct whose chord length is greater than its diameter, of suitable hydrofoil cross-section. Water flows into and through the duct from front to rear and in doing so passes through and over the mechanisms situated inside the duct. In order of position within the duct from the front these mechanisms consist of (a) an axial flow pump of one or more stages, (b) a mixing chamber and (c) a turbine of one or more stages.

In order that the present invention may be

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more fully understood, reference will now be made, by way of example, to the drawing accompanying the provisional specification which illustrates one form of propulsion unit according to the present invention.

Referring to the drawing, the propulsion unit consists of a shaped annular Duct 1 attached to the hull by a hollow strut 2 down which air or other gas may be passed to the interior of the duct. Within the duct is an axial flow pump comprising a multi-bladed rotor row or impeller 3 in front of a multi-bladed stator row 4, a mixing chamber 5 and a turbine comprising a turbine stator 6 and rotor 7, the rotor 7 being mechanically connected to the rotor 3 of the axial flow pump by a shaft 8. The axial flow pump and the turbine are carried on a streamlined central hub 9 and 10 made up of stationary portions 9 and rotating portions 10, the duct 1 being supported from the stationary portions of the hub by the axial pump stator blades 4 and by the turbine stator 6. Gas inlet holes in the wall of the mixing chamber 5 communicate with the interior of the hollow attachment strut 2.

The purpose of the axial flow pump is to increase the energy of the water flowing into the duct primarily in the form of increased pressure so that the pressure of the water entering the mixing chamber is considerably higher than the ambient pressure of the water outside the duct. In the mixing chamber gas is introduced into the flowing water in such a way that it is distributed reasonably uniformly in small bubbles over the whole cross-section, in this way a homogeneous two-phase flow is produced which behaves as a compressible fluid. The shape of the after portion of the duct is such as to cause this compressible fluid to expand thereby converting the pressure head in the mixing chamber into a velocity head at exit from the duct. During the expansion process the two-phase flow passes over the turbine which extracts the necessary energy to drive the axial flow pump. The remaining energy in the exhaust forms an exhaust jet whose momentum is greater than the momentum of the water entering the duct so that a useful propulsive thrust is generated.

There are two possible forms that the propulsion unit might take. The first one is that illustrated in the drawing where the unit is attached to the vessel it is propelling by means of a hollow strut down which gas or air is supplied from an engine in the vessel. This engine might be, for example, a gas turbine with a large by-pass ratio, or one driving a special air compressor. The air or gas can be ducted directly to the propulsion unit or fuel may first be burnt in it in order to raise its temperature before directing it to the unit. The second form that the propulsion unit may take is one where a water reactive fuel is injected directly into the water in the mixing chamber and there produces suitable quantities of gas to replace the gas supplied by the external engine in the first form of propulsion unit. Alternatively the gas may be stored in a liquid or solid state before injection into the duct.

One advantage of this new propulsion system, which is applicable to hydrofoil craft, hovercraft, conventional ships and underwater weapons, is that it is capable of producing a very high thrust for a small cross-sectional area and is, therefore, very compact for high powers and when used with a compact engine such as a gas turbine, it is very suitable for propulsion at high speeds as well as at normal propeller speeds. In addition it is particularly suitable for the propulsion of either hydrofoil or hovercraft because it is more efficient than either air or water propellers and does not require high power transmission shafts between the propulsion unit and the engine in the craft. Further, because of the absence of transmission shafts, the propulsion unit can be designed to swivel to produce large side forces for improved manoeuvrability. When used with water reactive fuels or liquid or solid gas storage the unit forms an attractive propulsion system for underwater vehicles.

In the propulsion unit illustrated a single stage axial flow pump and a single stage turbine are shown. In practice, both a multi-stage pump and a multi-stage turbine might be used and, in addition, the corresponding stages of the pump and turbine might with advantage (in order to achieve the optimum loading per stage) be driven at different speeds by being coupled together by separate shafts rather than all be driven at the same shaft.

WHAT I CLAIM IS:—

1. A marine propulsion unit comprising an annular duct within which water flowing therein is mixed with a gas in a mixing chamber to produce a homogeneous two-phase flow which behaves as a compressible fluid the pressure of the water entering the duct being increased by means of an axial flow pump situated within the duct forward of the mixing chamber and the shape of the after portion of the duct being such as to cause the compressible fluid to expand thereby converting the pressure head in the mixing chamber into a velocity head at the exit from the duct the fluid flow during the expansion process passing over a turbine from which the energy required to drive the axial flow pump is derived.

2. A marine propulsion unit according to claim 1 in which the rotors of the axial flow pump and of the turbine are coupled together by a common shaft.

3. A marine propulsion unit according to

claims 1 or 2 in which either the axial flow pump or the turbine or both have multiple stages.

4. A marine propulsion unit according to claim 3 in which corresponding stages of the axial flow pump and of the turbine are each coupled together by a separate shaft.

5. A marine propulsion unit according to any of the preceding claims in which the gas is supplied to the mixing chamber through a plurality of holes in the wall thereof communicating with the interior of a hollow attachment strut.

6. A marine propulsion unit according to any of claims 1 to 4 in which the mixture of gas and water in the mixing chamber is produced by injection of a water reactive fuel into the water therein.

7. A marine propulsion unit according to any of claims 1 to 5 in which the gas is stored in a liquid or solid state before injection into the duct.

8. A marine propulsion unit according to any of the preceding claims wherein the axial flow pump and the turbine are carried on a streamlined central hub made up of stationary portions and rotatable portions the duct being supported from the stationary portions of the hub by the axial pump stator blades and by the turbine stator.

9. A marine propulsion unit substantially as hereinbefore described with reference to the drawing accompanying the provisional specification.

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For the Applicant.

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1323871 PROVISIONAL SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*